

Exercises

- 7.1** Under what conditions can the sensor in Example 7.2 fail to identify blown fuses in capacitor units? How does this affect grid operation?
- 7.2** File `E7-2.csv` contains the current measurements and the conductor temperature measurements at a power line cable. It also contains the ambient temperature. Generate a scatter plot to show the *difference* between the conductor temperature and the ambient temperature versus the current.
- 7.3** File `E7-3.csv` contains the cell voltage measurements at a battery pack with three cells. Let V_1 , V_2 , and V_3 denote the voltage at the first, the second, and the third battery cells, respectively. Calculate and plot the following index to evaluate *cell imbalance* in this battery pack:

$$\frac{1}{\Gamma} \max_i |V_i - \Gamma| \times 100\%, \quad (7.1)$$

where Γ denotes the average voltage across the three battery cells.

- 7.4** File `E7-4.csv` contains the hourly wind speed measurements over a period of three weeks [493]. Answer the following questions:
- What is the minimum wind speed during this period?
 - What is the maximum wind speed during this period?
 - Plot the histogram for the wind speed measurements during this period.
 - What is the probability that wind speed is between 6 m/s and 9 m/s?
 - What is the probability that wind speed is between 3 m/s and 6 m/s?
 - If wind speed in the present hour is between 6 m/s and 9 m/s, then what is the probability that wind speed in the next hour will be between 3 m/s and 6 m/s? Note that this is a *conditional* probability.
- 7.5** File `E7-5.csv` contains occupancy measurements in a room.
- In what percentage of the time is the room occupied?
 - In what percentage of the time during off-peak hours (9:00 PM–8:00 AM), during mid-peak hours (8:00 AM–5:00 PM), and during on-peak hours (5:00 PM–9:00 PM) is the room occupied?
- 7.6** Consider the illuminance measurements that we previously discussed in Figure 7.13. What should be the dimming level of the lighting fixtures so that we have at least 400 lx of illuminance at each sensor location?
- 7.7** Suppose you park your EV at a charging station at work at 8:00 AM with an initial charge level at 1 kWh. The full charge capacity of your EV is 16 kWh.

Table 7.3 Price of electricity at the charging station in Exercise 7.7.

Hour	Price (¢/kWh)
8:00–9:00	13.0
9:00–10:00	13.9
10:00–11:00	12.5
11:00–12:00	14.1
12:00–13:00	13.3
13:00–14:00	14.8
14:00–15:00	15.1
15:00–16:00	15.3

You can charge your EV at 5 kW power rating at any time while you park. There are a 60% probability and a 40% probability that you will depart at 12:00 PM and 4:00 PM, respectively. You will know your departure time at 11:00 AM. The price of electricity is given in Table 7.3. Plan your charge schedule to minimize the expected value of the cost of fully charging your EV.

- 7.8** One month of driving and parking data is given for three EVs in file E7-8.csv. Zero means driving and one means parking [494].
- Calculate at what percentage of the time each EV is parked.
 - Plot the histogram for the *duration* of parking events for each EV.
- 7.9** Consider an EV charging station with two ports. File E7-9.csv contains the record of all EVs that are charged at this charging station over a period of one month. Calculate the *blocking probability* at this charging station, i.e., the probability that both ports of the charging station are occupied.
- 7.10** In Exercise 7.9, calculate the total charging load of each port of the charging station on each day. Accordingly, plot their monthly charging load profile.
- 7.11** How much is the total cost of electricity for the monthly bill in Table 7.2 if the energy usage is charged at 10.33 ¢/kWh (on-peak), 8.82 ¢/kWh (mid-peak), and 7.27 ¢/kWh (off-peak); and the peak demand is charged at 6.88 \$/kW (on-peak), 2.74 \$/kW (mid-peak), and 1.31 \$/kW (off-peak)?
- 7.12** File E7-12.csv contains the hourly average of real-time prices at a market location in a wholesale electricity market [465].
- At what percentage of the time is the real-time price negative?
 - At what time of the day do the negative real-time prices usually occur?
- 7.13** File E7-13.csv contains the hourly day-ahead market prices at the same market location and during the same period of time as in Exercise 7.12. At what percentage of the time is the hourly day-ahead market price higher than the hourly average real-time market price?
- 7.14** Files E7-14a.jpg and E7-14b.jpg contain two sky images that are taken at a PV site. Either visually or by using an image processing tool, identify what percentage of each image is covered by clouds. Briefly explain how this type of analysis can be useful in smart grid applications.